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ECONOMIC EFFECTS OF TIME LOSS IN PASSENGER TRANSPORT – EVIDENCE FROM SELECTED POLISH CITIES

Summary. Time is a necessary factor in processes of transportation. The economic value of travel time is the opportunity cost of the time spent on journey, so the reduction of travel time becomes the main goal of transport network users. Travel time losses in passenger transport are frequently observed in crowded cities, which are facing different types of traffic congestion. The article shows the analysis of the complicated causes of travel time loss, the need of implementing some simplifications during the estimation of the travel time value. Moreover the paper presents the most important results of the newest research on the discussed problem in Polish cities.

EFEKTY EKONOMICZNE STRAT CZASU W TRANSPORCIE PASAŻERSKIM NA PRZYKŁADZIE WYBRANYCH MIAST POLSKI

Streszczenie. Czynnik czasu jest zasobem niezbędnym przy realizacji procesu transportowego. Ekonomiczna wartość czasu w transporcie jest kosztem utraconych korzyści przez pasażera, stąd redukcja czasu transportu staje się jednym z głównych celów użytkowników jego. Straty czasu w transporcie pasażerskim są najbardziej odczuwalne w zatłoczonych miastach, w których występują różne rodzaje kongestii transportowej. W artykule została przedstawiona analiza skomplikowanych przyczyn strat czasu, uwypuklono również kwestię konieczności stosowania uproszczeń podczas prób szacowania wartości straconego czasu oraz syntetycznie opisano najważniejsze wyniki najnowszych badań obejmujących omawiany problem w transporcie w polskich miastach.

1. INTRODUCTION

Effects of time loss in passenger transport are not easy to identify, so the process of the estimation of their economic value is even more complicated. Despite the fact that many methods of estimation have been developed by European (e.g. British, Swedish, Dutch or French) researchers, the achievements in Polish literature in the field of precise valuation of travel time in Poland are still quite poor. It is important to emphasize that knowledge about economic effects of time loss in passenger transport could be useful in the creation of transport policies which should take into account benefits from reduced travel time costs. Moreover, this kind of knowledge may have an impact on transport users' choices between individual and public means of transport and on decision-makers in field of transport infrastructure investments.

The first aim of this article is to show main factors determining the difficulties which occur during attempts of the travel time valuation. Moreover, the paper explains the principal causes of travel time losses in urban areas which are considered to be the most difficult objects for this kind of studies. Secondly, the article brings the most important assumptions, results and conclusions from the research made by Deloitte and Targeo.pl on traffic congestion and its economic effects in selected seven Polish cities - Warsaw, Lodz, Wroclaw, Cracow, Katowice, Poznan and Gdansk.

2. THE TIME FACTOR IN PASSENGER TRANSPORT

2.1. The economic value of travel time

Many definitions of the term "transportation" include the time factor, saying that it is a change of space and time or rather a movement that allows to go through the space at a given time. It is obvious that time is a necessary factor in processes of transportation and that passengers have to spend a specified amount of time to fulfil their transport needs [9, p. 11]. If we take into account that in the theory of transport economics the value of time is an opportunity cost of the time spent on journey, it will be apparent that reduction of travel time becomes the main purpose of transport network users [4, p. 1]. Moreover, knowledge of the travel time in a transport network may also seem important for transportation analysts, decision-makers in field of transport policy or infrastructure investments. Transport users can benefit from travel time information and better schedule their trips, change the trip time or planned routes. At the same time information about travel time is also useful in monitoring network performance, observing congestion progression or detecting incident occurrence to provide users more detailed information [1, p. 1]. Each of these actions leads to achieve travel time savings, but the question is why it is worth doing? The answer refers to the recognition of the value of time as a category of transport costs.

To calculate precisely the generalised costs of the journey, it is necessary to take into account a combination of both monetary and non-monetary costs [4, p. 1-2]. In order to the fact that it is impossible to summarise or to compare these two types of costs, the travel time (a non-monetary cost) has to be estimated as a monetary value. Methods of estimating the economic value of travel time has been the subject of many scientific discussions and economic research. The role of time factor in economics began to be discussed with special emphasis from 1965 (Becker). The basis of the research is an assumption that from a microeconomic point of view, modelling urban travel demand is to introduce time and space in consumer theory. Consequently, there are three important aspects to discuss – how time enters the utility function, how to include time limitation and how to identify the relations between goods consumption and time allocation [5, p. 63].

Referring to the problem posed in the title of the article it is necessary to explain the reason of exploring the problem of time value separately in passenger transport, excluding freight transport. Firstly, the estimation of value of time is important and useful in all kinds of transport systems and networks, including all modes and types of transport, but for passenger and cargo transport there are quite different methods of calculation. Secondly, passengers often require more from infrastructure managers and operators than cargo transport users. This is due to the fact that cargo transport is focused on carriage of goods that need to be transported with the most efficient usage of means of transport at the lowest price, while passengers are the subject of transportation. Demands expressed by freight transport users are not valid for passengers, who are interested in the quality of service in a different way – i.e. speed, punctuality, time accessibility, regularity, frequency, rhythm, punctuality and directness etc. are often more important for them [10, p. 135].

While we are analysing the value of time in passenger transport it is worth underlining that we can identify different levels of difficulty in process of travel time estimation in various areas. It is more challenging to estimate it on urban roads than on freeways. Urbanised areas are characterised by interrupted flow nature caused by control devices, presence of shared lines and turning movements, existence of on-street parking, commercial access points and transit stops which are the main causes of the difficulty of precise estimations or predictions [1, p. 1-2]. Moreover, as it was mentioned before,

passengers have various and subjective demands on the quality of transport services, so the value of time varies widely from one user to another depending on the purpose of the journey.

To estimate the economic value of travel time it is indispensable to make some simplifications. In practice, very often two sets of valuation are used – working and non-working time [3, p. 2]. This division helps to calculate more precisely the value of travel time as a whole, because travel time spent in the course of work and outside the work should be estimated differently. The value of working time can be named as the opportunity cost of that time to employer that is generally equivalent to the wages of the employee. Unfortunately, this assumption does not guarantee that the estimation of the value of work time spent on travel is free of difficulties, because it is necessary to take into consideration the mode of transport used by the employee. Time spent travelling by train can be used to carry out some work, while time spent in car not, so the value of time spent on journey may not exactly correspond with the salary of the traveller. However, the estimation of non-working time is even more imprecise and difficult, because it is based on revealed preferences or stated preference analysis which means that real or hypothetical travellers' choices between slower, cheaper and faster, more expensive transport is examined [4, p. 1-2].

Research on various methods of the value of travel time estimation is crucial for developing Intelligent Transportation Systems, reducing congestion and saving time which is a matter of interest from both a micro and macroeconomic viewpoint. It is very important to develop this kind of methods of estimation which do not cause very high costs of data collection, so that the travel time savings could be really reachable and evident in the final settlement of costs and benefits [1, p. 2].

2.2. Main causes of the time loss in passenger transport – urban areas

Factors characterising urban areas in a context of functioning of transport systems has been already mentioned in this article. On one hand control devices, shared lines, turning movements or on-street parking are solutions introduced to organise transport in urban areas which are facing the problem of intensified movement of people and goods. On the other hand, these solutions can be recognised as causes of traffic congestion resulting in time loss in transport. It is worth understanding that both, transport problems affecting urban areas and solutions introduced for better traffic management are the undeniable proofs that overloaded transportation urban networks are the main issue needed to be resolved. Traffic congestion is discussed in this paper as a main cause of time loss in passenger transport in urban areas.

Traffic congestion can be defined as a situation in which the demand for the use of infrastructure prevents the free movement at the maximum permitted speed of traffic. There are many types of traffic congestion extracted by using different classifications. In some studies [6] the division into two main types of congestion is presented – the congestion on the transport network and the congestion in the means of transport. Moreover, the first type can be identified as congestion on linear transport infrastructure or on transport hubs, stops, stations, harbours, etc. Another classification shows six types of traffic congestion:

- single interaction – occurs between two vehicles, whereby the speed of one of them is adversely reduced,
- multiple interaction – takes place between multiple vehicles and occurs at a higher level of traffic than a single interaction,
- bottleneck – occurs when a capacity of infrastructure is lower than a capacity of the surrounding network what causes congestion on selected sections of the infrastructure,
- triggerneck – occurs often as a consequence of bottleneck, when congestion on selected sections turns into congestion on the whole network,
- general density – occurs when traffic congestion in one mode of transport has a negative impact on other modes (even if they work independently),
- traffic congestion caused by control devices [6, p. 10].

Urban areas with a high population density are burdened with an accumulation of passengers' needs. Travelling to work or school (obligatory transport needs) causes traffic peaks. In Polish cities optional trips are mainly intensified during the weekend. It is clearly visible that sources of transport needs in the city are mostly scattered, but destinations are concentrated. Additionally, another source of congestion problem in European cities is in the narrow building and a lack of possibilities to expand transport infrastructure. If the infrastructure is being developed, traffic congestion occurs during the realisation of infrastructure investments [6, p. 10]. Nowadays, the subject of research is also traffic congestion due to travelling to shopping centres - unfortunately some of them are located in city centres in Poland, what is the cause of the congestion. What is distinctive for Polish citizens, trips to shopping centres take place mainly during the weekend, because these centres are open on Saturdays and Sundays. Research on this type of congestion has been made in Cracow (Poland). The results showed that the smallest amount of journeys to the selected shopping centre occurs on Mondays, within the week it increases to reach on Saturday one-third larger amount compared to Friday and about three quarters compared to Monday [2].

3. TRAVEL TIME LOSS IN SELECTED POLISH CITIES

3.1. The background of the selected study

Transport systems of the biggest cities in Poland are dominated by private car journeys. It is obvious that users of public transport, cyclers and those who are reaching destinations by walk are also affected by the negative effects of traffic congestion. Nevertheless, the problem of delays on urban networks are caused and at the same time most perceptible by the private cars users. This is the main reason of choosing this group of travellers as the subject of the analysis which is presented in this paper.

The research on traffic congestion in seven Polish cities: Warsaw, Lodz, Wroclaw, Cracow, Katowice, Poznan and Gdansk was made by the global consulting company Deloitte and creators of the Polish website Targeo.pl which provides navigation service and current information about traffic congestion in city centres. The study focused on a data collected in 2010, 2011, 2013 and 2014. Last two reports were published in March 2014 and 2015. The valuable source of knowledge contained in these two last reports is a comparative analysis of the impact of the transport time losses on the economies of selected seven cities in three (and four in 2015) different years.

The study of the occurrence of congestion was based on measurements of an actual vehicle speed on selected road sections. The basis was the GPS data, collected in real time from more than 100 000 moving vehicles, which while driving provided information about the location, speed and direction of the travel, all at intervals of not more than 60 seconds. The analysis covered a road network of the seven cities - a total of over 29 000 km of roads. What is important, the collection was made in October (in every analysed year), because this month is considered to be the most reliable for measuring traffic due to the ongoing school and academic year and moderate weather conditions [7, p. 5].

Within the research a specific unit, the so-called *korkometr* (delay-timepiece) was created. The *korkometr* is an indicator of the relative delay caused by traffic congestion in relation to the free flow. The free flow data was collected beyond traffic peaks. For analysis of many routes or a part of the transport network, the delay is given as the average delay time on every 10 km of the route. When a single specific route (i.e. selected bottleneck) is analysed, the delay is given as the time delay for the whole selected section. In addition to the calculation of delays, the study focused on selecting parts of the network which could be considered as bottlenecks in cities' transportation systems [7, p. 5].

As it was discussed before, the process of travel time valuation is complicated and some simplifications are necessary to be made to achieve comparable results. Assumptions of the analysed research seem to be controversial - simplifications concern:

- an assumption that the time spent on journeys with delays could alternatively be spent at work only,

- an assumption that unemployed people are not using private cars,
- an estimation of the amount of people travelling to the places of work by car is based on data provided by public transport carriers and organizers about usage of public transport,
- an assumption that drivers are using Fiat Panda with a petrol engine with a capacity of 1.1 litres,
- the price of gasoline used in the model, which is the average annual for the whole country, and not for a statistical month (October) analysed in this research,
- the lack of external costs estimation (i.e. environmental costs – CO_2 emissions, costs of loss of life and health caused by air pollution and noise as well as by accidents on roads, etc.) [7, p. 41].

Some of presented simplifications and assumptions can be considered cautious or even inappropriate and it is predictable that they understate the estimated opportunity costs. However, authors of the report of the discussed study underlined that their purpose was not the maximisation of costs, but to present a scale of the problem of economic value of time loss in passenger transport [7, p. 41].

3.2. The results of the estimation – value of travel time loss in Polish cities

In 2014 all employed persons of seven selected Polish cities lost in the traffic congestion 13.7 million PLN per day, 300.7 million PLN per month and more than 3.6 billion (3 600 million) PLN per year[1] [8, p. 55]. In 2013 losses were a bit smaller – 13.1 million PLN per day, 289 million PLN per month and almost 3.5 billion (3 500 million) PLN per year. Comparing 2013 to the years 2011 and 2010 there was a decrease of almost 52 million PLN and over 31 million PLN. This decrease was identified despite the fact that the population, a number of drivers and salaries were steadily growing [7, p. 42]. The reason for this trend may lay in the developing transport infrastructure and introduced improvements in field of traffic management and transport policy of the cities. Congestion charges, cycle hire schemes, ITS solutions for better free flow are the good examples of solutions facing the problem of time loss in passenger transport in urban areas. However in 2014 the positive trend turned and bigger losses were identified.

From the microeconomic viewpoint, in 2014 the average traffic congestion cost for one driver reached an amount of 3.034 PLN per year, what is about 5,7% of average yearly wages of employees from selected cities. In 2013 this cost was 2.905 PLN per year, what was about 5,8 % of average yearly wages. The structure of factors influencing on presented costs differs in every analysed city. Differences refer to a number of drivers, salaries and time spent on journeys. Nominally, the biggest losses are noticeable for drivers in Warsaw (3.701 PLN per year), Wroclaw (3.539 PLN per year), the smallest are in Gdansk (2.428 PLN per year), Lodz (2.408 PLN per year) and Katowice (2.973 PLN per year). However, taking into account the value of the average salary in selected cities, the results are changing. Relatively, e.g. in 2013 the lowest costs of transport time loss per year are noticeable in Katowice (3,9% of average yearly wage in this city) and the highest costs occurs in Cracow (6,8% of average yearly wage in the city) [7, p. 43-44]. Analysing the year 2014 the lowest costs occurs in Gdansk (4,1% of average yearly wage in this city) and the highest costs occurs in Wroclaw (7,3% of average yarly wage in e city) [8, p. 54-56]. The scale of the results is quite spread for each year, as it is shown on Fig. 1.

[1] Polish Zloty (PLN) to Euro (EUR) exchange rate on April 1st, 2015 was: 1 PLN = 0.25 EUR

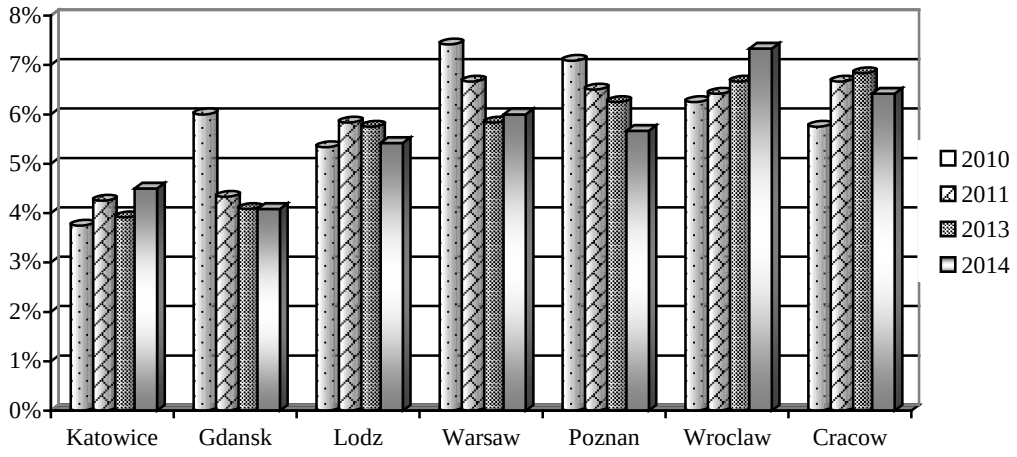

Fig. 1. The annual cost of congestion as a percentage of yearly wages in Polish cities in 2010-2014
Rys. 1. Roczny koszt kongestii jako procent rocznych wynagrodzeń w miastach Polski w latach 2010-2014

The analysis from the macroeconomic point of view should not omit the estimation of costs for the whole economy. It is worth emphasizing that this estimation is based on comparison of the global costs for the transport users (drivers) and tax revenues of the state budget (due to VAT and excise taxes). Taking into account that indirect taxes are a half of the price of gasoline, in 2013 the state budget had an income of almost 520 million PLN, what was a decrease of more than 18 million compared to 2011 and 2010. However, the most important result concerns the difference in costs for drivers and benefits for the budget which in 2013 for selected seven Polish cities was identified as a cost for the economy at the level of 2.945 billion PLN (0.18% of Polish GDP in 2013) [7, p. 44-45]. In 2014 this cost was on the same level – 0.18% of Polish GDP in 2014. Between 2010-2011 this cost was on the level of 0.19% GDP, so the positive change is visible at the macroeconomic level.

4. SUMMARY

The estimation of the travel time value is complicated, but very important for better use of all modes of transport and better planning, and organisation of transport networks in cities. The research discussed in this paper does not show the problem of external costs caused by traffic congestion. All of environmental costs, including the intensified CO_2 emissions, and of course costs of car accidents, should be classified as another very important issue for a parallel discussion. Moreover, the analysis presented in the article proved that the knowledge about the economic value of travel time loss is crucial for both users and managers or developers of the city transport system. Awareness of the scale of the value of losses and accordingly of the possibility of gaining some savings should be the motivation to shape model behaviours that will facilitate all types of journeys across the city. It is also important that not only new cost-intensive infrastructure investments are needed to save time – introducing organisational and management solutions is the significant key to the reduction of travel time costs.

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